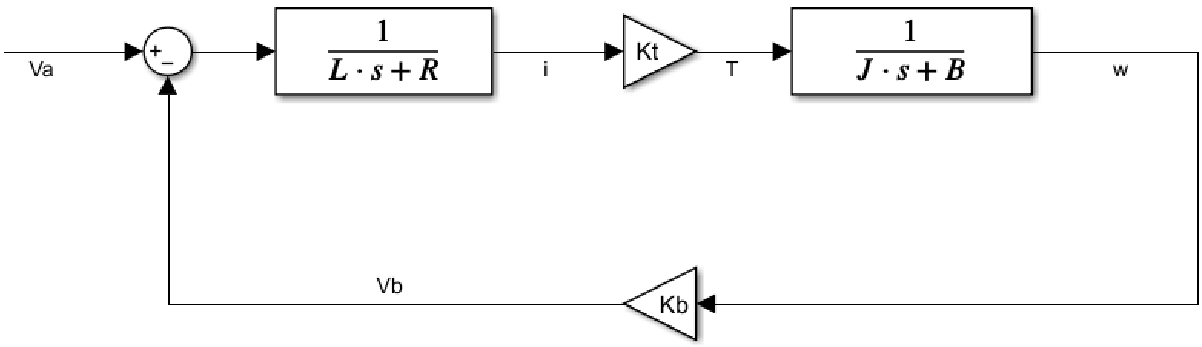
MEE427 PID CONTROL – BRUSHED DC MOTOR MODELLING

Group Number:

Group Members:

Armature Controlled Brushed DC Motor Block Diagram Model



The purpose of this modelling work is to estimate parameters that are given in the block diagram representation empirically.

Pre-Modelling

1) Calculate the PWM frequency that you will supply with the formula below.

$$PWM\ Period = 4x[(PR2) + 1]x[TMR2\ Prescale\ Value]xT_{osc} \quad (1)$$

where,

- PR2 is the Timer2 preload value (could be 255)
- $T_{osc} = 1/f_{mcu}$
- TMR2 is the Prescale Value and it can be 1, 4 or 16

For example;

- PR2 = 255
- Microcontroller frequency = 8MHz
- Prescale = 16
- ⇨ PWM Frequency = 488 Hz

The CCS Timer2 configuration has the following form, which can be found in supplied codes as well;

setup_timer_2(mode, period, postscale);

where,

- Mode is TMR2 Prescale Value
- Period is PR2
- Postscale is not used in the determination of the PWM frequency (keep it 1)

Usage for example;

setup_timer_2(T2_DIV_BY_16, 255, 1);

2) Before connecting electric motor to motor driver, edit the supplied code – 1 according to your hardware requirements and upload to your microcontroller. Measure the PWM frequency of the output with an oscilloscope and compare it with the result you have found.

3) Disconnect the microcontroller from your circuit. By using a function generator, set the PWM frequency to that you have measured in the previous step. Connect its output to motor driver in order to rotate the electric motor. As the motor rotating examine if the filter outputs are working properly in both directions. You should change the PWM duty cycle percentage in order to examine if the filter output voltages vary accordingly. Be sure that filter works properly within the limits ($V_f \geq 0V$ & $V_f \leq 5V$).

4) If the filter outputs work properly within the limits, connect the microcontroller to your circuit. Rotate electric motor to both directions with the supplied code – 1 (You should edit the code according to your hardware requirements).

5) For different PWM signals, observe the embedded encoder signals by using an oscilloscope and determine the relation between PWM signals and rotational velocity. It should be done in both directions.

PWM (%)	Direction	Measured Rotational Velocity (ω)	Direction	Measured Rotational Velocity (ω)
10	CW		CCW	
20	CW		CCW	
30	CW		CCW	
40	CW		CCW	
50	CW		CCW	
60	CW		CCW	
70	CW		CCW	
80	CW		CCW	

Modelling

1) Estimating resistor (R) parameter (Assume that L is negligible);
Measure the resistor between motor terminals.

$$R = \boxed{}$$

2) Estimating back-emf constant (K_b);
The relation between the rotational velocity and the back-emf voltage can be found with the Equation 2.

$$V_b = K_b\omega \tag{2}$$

This linear relation can be determined by collecting data with different speeds.
Fill in the table below.

PWM (%)	Direction	Measured Rotational Velocity (ω)	Back-emf voltage (V_b)	Direction	Measured Rotational Velocity (ω)	Back-emf voltage (V_b)
10	CW			CCW		
20	CW			CCW		
30	CW			CCW		
40	CW			CCW		
50	CW			CCW		
60	CW			CCW		
70	CW			CCW		
80	CW			CCW		

3) Estimating torque constant (K_t);
The relation between the current and the motor torque can be found with the Equation 3.

$$\tau_m = K_t i \tag{3}$$

This linear relation can be determined by collecting data under different loads.
Use the built-in current filter that is placed on the motor driver (You don't need to use yours). Its output is located on the control pins (ctrl pin 4 => CFB). According to motor rotation direction, the output voltage is fluctuated about the offset voltage (about 2.5Volts). The procedure to estimate torque constant (K_t) is as below.

- Find the exact offset voltage (V_{offset} when the motor is stationary)

$$V_{offset} = \boxed{}$$

- Fill the table below.

PWM (%)	Direction	Measured Current (A)	Measured Torque (Nm)	$V_{cfb} - V_{offset}$ (ΔV)	Direction	Measured Current (A)	Measured Torque (Nm)	$V_{cfb} - V_{offset}$ (ΔV)
10	CW				CCW			
15	CW				CCW			
20	CW				CCW			
25	CW				CCW			

4) Estimating friction coefficient (B);
The relation between the motor torque and the motor speed can be found with the Equation 4.

$$\tau_m = K_t i = J\frac{d\omega}{dt} + B\omega \tag{4}$$

If the motor speed reaches to its steady state condition ($^{d\omega}/_{dt} = 0$), then the relation between the motor velocity and the motor current can be found, which is the friction coefficient.
Fill in the table below.

PWM (%)	Direction	Determined Rotational Velocity (ω)	Determined Current (A)	Direction	Determined Rotational Velocity (ω)	Determined Current (A)
10	CW			CCW		
20	CW			CCW		
30	CW			CCW		
40	CW			CCW		
50	CW			CCW		
60	CW			CCW		
70	CW			CCW		
80	CW			CCW		

5) Estimating rotational inertia (J);
The rotational inertia can be estimated with the same Equation 4. After applying instant nominal DC voltage (12 Volt step input), it is needed to save the instant data of current (i), rotational velocity (ω) with elapsed time. During the acceleration, the data should be plotted with respect to elapsed time and from the slope, the rotational inertia value can be estimated.